KANSAS CITY'S UNION STATION RAMP BRIDGE
A UNIQUE APPLICATION OF SPREAD BOX BEAMS

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ABSTRACT

Built in 1914, Kansas City's Union Station is a major attraction for culture, education and entertainment. Parking and pedestrian access to this historic building needed improvement. Burns & McDonnell, serving as design-builder, provided design and construction services for a new ramp bridge to carry vehicles and pedestrians from the front of this grand building to an existing parking garage. Prestressed concrete box beams provided the shallow depth aesthetic desired for this site. Unique geometry was a challenge. The completed structure includes a pedestrian overlook with a stunning view of the downtown skyline, further enhancing the visitor experience to Union Station.

KEYWORDS
Historic, Pedestrian, Design-Build, Box Beams

INTRODUCTION

Built in 1914, Union Station Kansas City is a major attraction for culture, education and entertainment. The facility is a historical landmark and civic asset which was extensively renovated and reopened to the public in 1999. Union Station Kansas City is currently home to Science City science center, the Model Railroad Experience, the Arvin Gottlieb Planetarium, the Regnier Extreme Screen Theatre, the H&R Block City Stage, unique shops and restaurants, and a busy Amtrak station. In addition, Union Station regularly hosts world-class traveling exhibitions and community events.

Parking and pedestrian access to this bustling facility needed improvement. Burns & McDonnell, serving as design-builder, was selected by Union Station Kansas City to design and construct a new ramp bridge to carry vehicles and pedestrians from the front of this grand building to the third level of the existing West Yards parking garage.

The ramp bridge was part of the $7.8 million western expansion project, constructed in 2016. Burns & McDonnell provided architectural and engineering design and construction services for the entire project. This integrated and dynamic project delivery method allowed the client to provide input to the design as construction progressed. The expansion project also included a modernization of the streetscape in the "front yard" of this majestic building as shown in Figure 1, an updated eastern plaza to incorporate the terminal station for Kansas City's new streetcar system, and improved bus access to the facility for school groups. Union Station has truly returned to its roots as a transportation hub for the region.

Figure 1 – Historic Union Station in Kansas City

In addition, one of the most exciting features of the 2016 expansion project included a sprawling events plaza for community-based events, located immediately north of the new ramp bridge. The first outdoor extension of Science City is adjacent to the events plaza and features interactive exhibits based on the concepts of simple machines. The new ramp bridge includes a pedestrian overlook which extends toward the events plaza and outdoor exhibit space as shown in Figure 2. This overlook, designated as Kansas City's newest "selfie spot," also has stunning

views of the downtown skyline to the north and the majestic National World War I Museum at Liberty Memorial to the south.

Figure 2 – New Ramp Bridge overlooking downtown Kansas City

THE DESIGN PROCESS

Burns & McDonnell worked closely with Union Station corporate, operations and maintenance personnel to understand the specific needs of the facility and its events. Previously, the West Yards parking garage was only accessible by driving a circuitous route around the back of the building, nearly a half mile from the main entrance. Visitors to the facility found this parking situation to be frustrating, particularly for large events with a specific start time. In addition, once parked in the four-level garage, pedestrians had to travel down to ground level, cross the north lot and a local street, enter the back of the building and take an escalator up before finally reaching the building's Grand Hall. Union Station management wanted to improve this access, and to make the pedestrian approach to the building part of the overall visitor experience.

Burns & McDonnell presented several schemes for the ramp bridge to Union Station in a series of informal design charrettes intended to promote discussion about the vision for the project site. Since most of the project relies on private funding, a strict approach to budget was maintained. Original ideas for the ramp bridge, including a "sine wave" structural shape, were set aside for a more economical approach. The project team also determined that a ramp structure with one-way vehicular access into the garage and a wide two-way pedestrian path and overlook was best suited to serve the access needs.

Located at the west end of the Union Station building, the Carriage Pavilion and its roof structure were included in the 1999 renovation. This area was previously used to drop off passengers at the Grand Hall by horse-drawn carriage. In more recent years, the Carriage Pavilion had been used by delivery trucks serving the post office inside the building. As part of the expansion project, this area has been converted to a passenger drop-off once again, and also allows vehicles

to access the ramp bridge and parking garage directly from the front of the building. The traffic crunch for major events has been alleviated with the additional garage entrance into the third level of the garage.

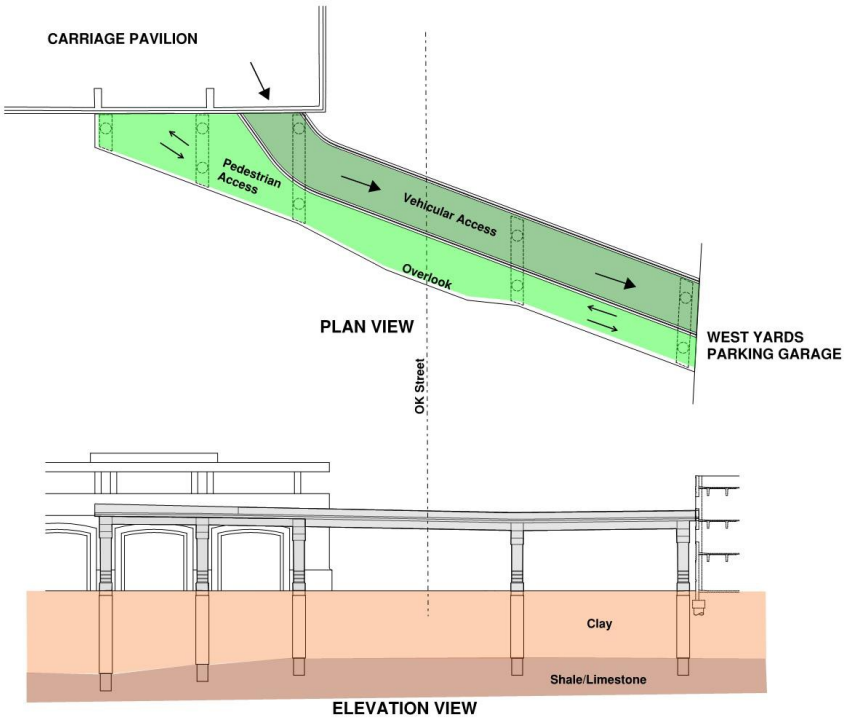

Figure 3 – New Ramp Bridge Plan and Elevation

Specific pedestrian needs have also been addressed with the new structure. The pedestrian path is ten feet wide to allow for two-way traffic and ample room for families with strollers visiting the attractions. It is now possible to park in the garage and walk into the Grand Hall at the same level, which has greatly improved the pedestrian experience. In addition, a 4'-0" (1.2 m) wide overlook juts out from the path at the center of the bridge, as shown in Figure 3, to provide a location to stop and take in the 360 degree view of the Kansas City surroundings.

The span arrangement for the bridge was controlled by horizontal clearance to the local access road OK Street, and was also set to frame the existing arches at the base of the Carriage Pavilion, resulting in spans of approximately 33'-33'-75'-57' (10.1 m – 10.1 m – 22.9 m – 17.4 m). The bents were set perpendicular to the Carriage Pavilion building except for the garage bent, which was set parallel to the garage. This resulted in some unique geometric challenges. First, there are no bridge abutments. In addition, the ramp ends and the expansion joints are oriented nearly 90 degrees apart. A detailed analysis of the temperature effects of the structure was performed for the expansion joint design, which included the movement of the parking garage. Finally, the ramp transitions to a triangular shape near the Carriage Pavilion to widen the pedestrian access, which made traditional girder framing a challenge, as shown in Figure 4.

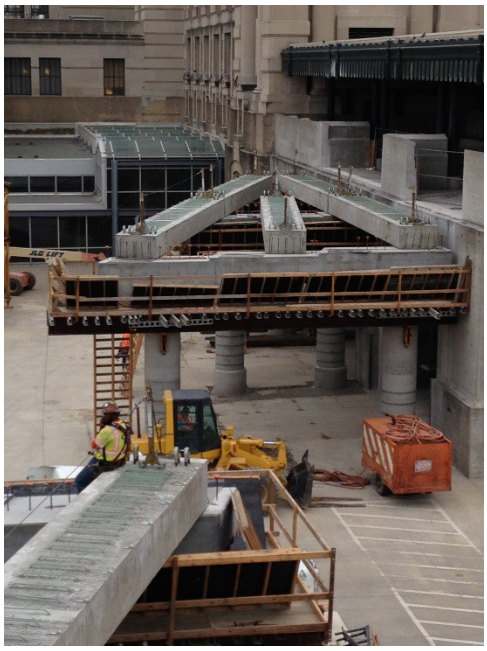

Figure 4 – Unique Framing near Carriage Pavilion

Prestressed concrete spread box girders were selected for the superstructure system. These were preferred over steel girders or concrete I-girders because of their clean and low profile aesthetic, and because a "heavy" structure was desired to compliment the aesthetic of the massive Union Station building.

Also, because this bridge is located in an urban environment, Union Station management required a "pigeon-proof" structure with no ledges, crevices or other nesting spots that would attract birds. Traditional cast-in-place concrete diaphragms at the pier caps were the cost-effective and clean-lined solution, as shown in Figure 5.

Figure 5 – “Pigeon Proof” Structure

Another unique challenge of the design was the bridge drainage. The Carriage Pavilion and the third level of the parking garage are at roughly the same elevation. The bridge is nearly 200’ (61.0 m) long and 28’ (8.5 m) wide, and will catch significant water during a rainfall event. Ideally, no storm water from the bridge would be allowed to flow into the Carriage Pavilion or the garage. Extensive drainage piping would visually clutter the clean lines of the structure and no inlets were allowed to be placed in the pedestrian path. The solution was to “warp” the bridge deck towards a single downspout hidden behind the south end of one bent, as shown in Figure 6. A series of drain inlets were placed in the vehicular roadway to receive water, including water flowing through open slots in the median barrier from the pedestrian path.

Figure 6 – “Warped” Bridge Deck Drainage

Much discussion and effort were given to the design of the pedestrian and vehicular railings for the bridge. The advantage to design-build projects is that changes can continue to be made to the design aesthetic as the project is taking shape and becoming a reality. This can also be a source of frustration for all parties if modifications are not communicated clearly. For this project, cost-effective concrete vehicular barriers were provided at the south fascia and median, and custom precast concrete railings were provided at the north pedestrian fascia. After the box girder superstructure and precast slab panels were erected, aesthetic treatments were added to the south fascia railing and the pedestrian railing was modified from stainless steel panels to the precast concrete panels. Acting as a one-shop design-builder, Burns & McDonnell was able to seamlessly communicate between the client and the architects, bridge engineers, contractors and fabricators to successfully deliver the desired aesthetic for the bridge barriers and railing.

FABRICATION AND INSTALLATION OF PRECAST COMPONENTS

The 27” x 48” (0.7 m x 1.2 m) box beams were fabricated at Coreslab Structures in Kansas City, KS. Eleven beams ranging in length from 31’-0” (9.4 m) to 74’-1” (22.6 m) were required for the project. The Burns & McDonnell bridge engineers worked closely with Coreslab to simplify and economize the box beam design, such as duplicating strand patterns to allow multiple beams to be cast in one bed as shown in Figure 7. Prestressing strands were extended and bent up at the ends of the boxes to provide connection at the cast-in-place diaphragms as shown in Figure 8. The boxes were cast with square ends, and the cast-in-place diaphragms were meticulously detailed to avoid conflicts at the ends of box beams. Additional aesthetic enhancements were not required for the box girders.

Figure 7 – Polystyrene Void in Precast Bed

Figure 8 – Box Beams Awaiting Delivery

The box beams were shipped just 10 miles (16 km) to the Union Station project site and erected on the bents. The beams were seated on plain neoprene bearing pads. The biggest lift was about 31 tons (28,000 kg), which was easily handled by the equipment on the small site as shown in Figure 9.

Figure 9 – Box Beam Erection

Precast deck panels were selected to be used in the superstructure system to speed construction, as shown in Figure 10. Again, close coordination with Coreslab ensured a perfect panel fit with the flaring and skewed box girder framing near the Carriage Pavilion. Panels slightly wider than standard panel widths were allowed because of the reduced vehicular wheel loading. Prestressed panel designs are typically controlled by HL-93 wheel loads. Design loading for the Union Station ramp bridge included 100 psf (690 kPa) pedestrian loading, 64 psf (440 kPa) vehicular loading or an H-5 maintenance vehicle, which has an 8 kip (3,630 kg) axle. This design loading allowed for snow plow equipment or other light maintenance vehicles to access the bridge, and also for the full bridge width to be packed with pedestrians, as for a mass exit from a large event at Union Station.

The framing and overall geometric control for the bridge was complicated. Unlike a typical highway or railroad bridge, there was no established stationing or obvious tie to set the horizontal control. The bridge was detailed, fabricated and constructed using spatial coordinates at the location of the nine drilled shafts. This was unique but manageable. As shown in Figure 11, a baseline was established from these coordinates, using a line parallel to the northernmost drilled shafts and the north fascia of the bridge. This baseline was used to set the geometry for the box girders and precast deck panels. Coreslab produced shop drawings and fabricated the girders and deck panels using this baseline, ensuring a perfect fit into the framing system.

Figure 10 – Precast Deck Panels

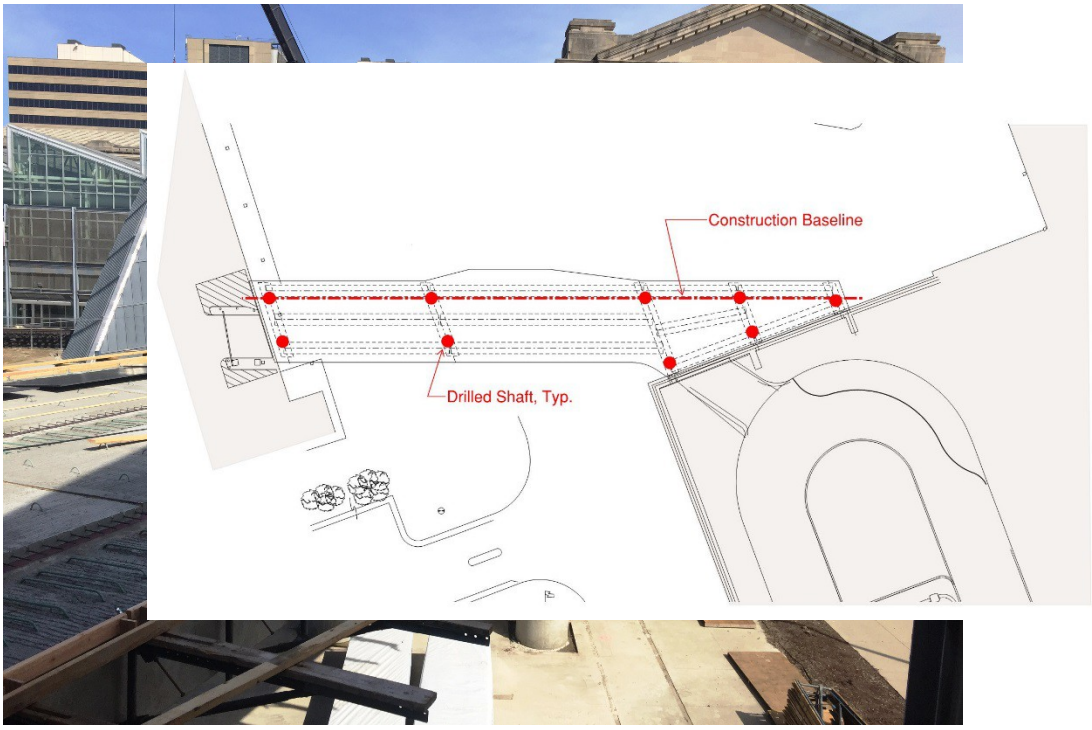

Figure 11 – Baseline Geometry System

A precast system for the pedestrian railing was desired for its smoother and more consistent finish. The rail panels were fabricated in lengths up to 15’-0” (4.6 m) and were installed at the north slab fascia between cast-in-place concrete pilasters. Coreslab Structures in Marshall, MO fabricated the rail panels and, similar to the box beam fabrication, close coordination on the geometrics was critical. The metal panel forms were custom crafted in the Coreslab shop and the spaces between the balusters were formed with Styrofoam, as shown in Figure 12. The rail panels were reinforced with epoxy-coated steel designed for pedestrian loading.

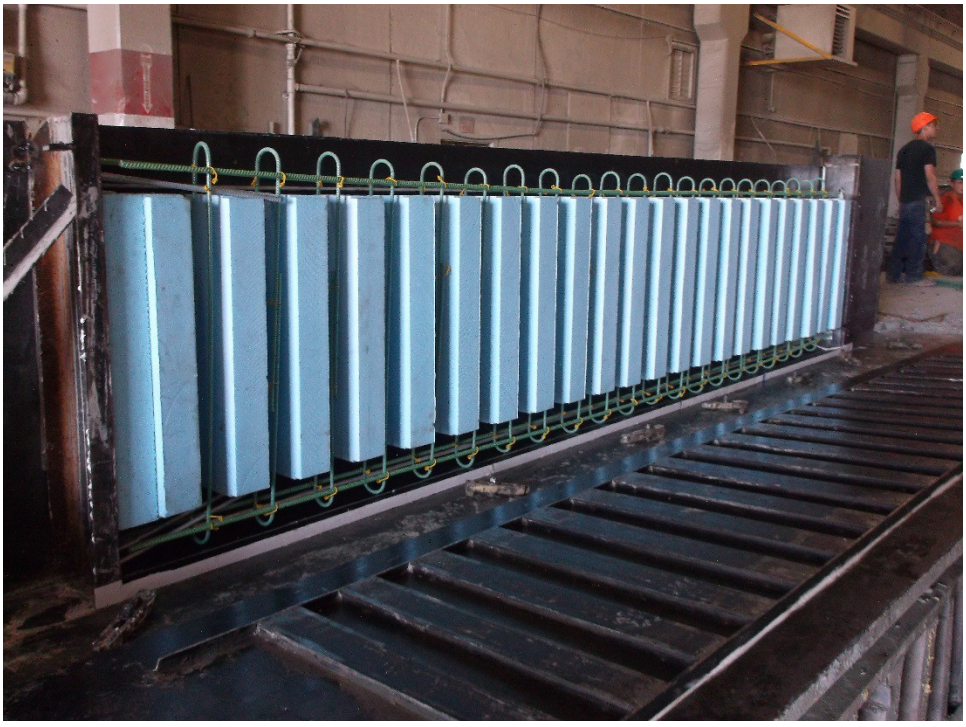

Figure 12 – Precast Rail Panel Formwork

Figure 13 – Precast Rail Panel Erection

The rail panels were shipped to the site and erected between pilasters as shown in Figure 13. Only a ½" gap (13 mm) was allowed between rail panel and pilaster, and all panels fit up well on site. Unlike the box girders and deck panels, the precast rail panels were detailed after substantial construction was complete. Fit up was ensured from as-built measurements between the pilasters. Hidden connections ensure a consistent appearance. After welding a jump plate to embedded plates in the pilaster and the precast rail panel as shown in Figure 14, precast end posts were doweled into the pilaster to hide the welded connections.

Figure 14 – Welded Connections for Precast Rail Panel

The expansion joint at the parking garage, which accommodates movement primarily perpendicular to the joint, is a typical compression seal. The expansion joint at the carriage pavilion, which accommodates movement primarily parallel to the joint, is a strip seal. Careful detailing of the end pilasters and cover plates over the joints at the pedestrian path were required due to the geometry at the ends of the bridge, as shown in Figure 15 and 16.

Figure 15 – Joint at Carriage Pavilion

Figure 16 – Joint at Parking Garage

RESULTS

The new Union Station ramp bridge, which opened to traffic in July 2016, provides direct access for vehicles and pedestrians visiting Kansas City's historic Union Station and its many attractions. The total cost of the bridge and related improvements to the Carriage Pavilion and parking garage was approximately $2.3 million, which included design and construction management services.

Figure 17 – New Bridge at Parking Garage

The ramp bridge also enhances the experience of visitors to Union Station events by providing stunning views from the pedestrian overlook. The structure also brings a “heavy” but clean and low profile aesthetic to the surrounding area, complimenting both the majestic historic building and the new north festival plaza and outdoor exhibit space.

Figure 18 – New Bridge at Carriage Pavilion

Figure 19 – New Bridge with Lighting